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Dynamic Pricing in B2C Based on Online Product Reviews

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Abstract

To study how e-tailors should fix the price to influence word-of-mouth to maximize profits, this paper comes up with a dynamic pricing model based on online product reviews. Customers base consumption decisions on the principle of utility maximization. A lower price can lead to more positive reviews and improve the utility, but it may reduce the profit. The model gives the optimal pricing strategy for the e-tailor in a duopoly market competing with an offline retailor. The analytical results show with the increase of online reviews, the optimal pricing of the e-tailor increases and the growth rate declines.

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Keywords: dynamic pricing;online product review;B2C;game theory

1 Introductions

As the business model of information society, electronic business has influenced human life greatly and is challenging traditional management theory. B2C is quite different from the physical retailing store in shopping model. The differences between B2C and the physical retailing store in product presence, consumer group and service time lead to the distinction in pricing strategy.

Dynamic pricing is the dynamic adjustment of prices to consumers depending upon the value these customers attribute to a product or service[1]. The advent of electronic business reduces trade cost of dynamic pricing. Market uncertainty and fierce competition also motive e-tailors to adopt dynamic pricing to maximize profits.

B2C websites allow consumers to comment on the products they have bought. The Online product review is one of major components of IWOM, and it has significant impact on consumption decision of online shopping[2-3]. The pricing of B2C directly affect perceived utility and comments made after

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purchase, thus determining the sales volume and profit of products. Therefore, considering the impact of online product reviews on pricing is of great importance for e-tailors to reasonably fix its price and increase profits.

2 Literature reviews

Pricing models in posted price mechanisms mainly divide into 3 categories: models based on inventory, models based on customer information and models based on market competition. Among dynamic pricing researches based on inventory, Federgruen and Heching[4] studied optimal pricing and inventory strategies when facing an uncertain demand. They also discussed the quantity rule between the optimal strategy and corresponding profits. Elmaghraby and Keskinocak[5] summarized the literature and practices in dynamic pricing. Among dynamic pricing researches based on customer information, Rusmevichientong [6] depended on customer preference data from Auto Choice Advisor website to fix prices for GE motors based on non-parameter method, and they compared their method with other methods and data resources. Morris [7] studied how to apply customer preference data to airline business, and proposed reserve pricing strategy and seat releasing strategy. Among dynamic pricing researches based on market competition, Bernstein and Federgruen[8] investigated the equilibrium behavior of decentralized supply chains when retailers face demands of which the distribution depends on its own price as well as those of competing retailers. Cao [9] examined the use of leader-follower games, cooperative games, and two person nonzero sum games in internet pricing.

There are only few researches that consider the effect of IWOM on pricing. Xiaoming Yan and Ke Liu[10] studied the optimal production and sales polices for a new product during the lifetime of the product under the influence of word-of-mouth to maximize profits. Xinxin Li and Lorin M Hitt[11] established a model to analyze the impact of online product reviews on the optimal price and consumer welfare, and they used the data collected from digital camera market to verify its theoretical result empirically. Yipeng Liu et al[12] developed an analytical model with software diffusion to examine the optimal pricing strategy for a spreadsheet software product under the effects of both piracy and word-of-mouth through its life cycle.

This paper studies how to take advantage of online product reviews to fix the price reasonably in duopoly market to maximize profits from the perspective of e-retailors.

3 Analytical model

H1: There are only two retailers selling the same product in the market- a pure e-tailor and an offline retailer. The two retailors do not cooperate to fix the price. Both of them can collect all the information they need in pricing and adjust their price quickly. Because of the uncertainty of market, both sides aim at maximizing profits of the present stage.

H2: Customers who scan the website of e-tailor and have the willingness to buy the product believe online product reviews are reliable. They also trust expert comments and product introduction.

H3: The quantity of information customers need when making a consumption decision follows even distribution [0,1]. We assume that the quantity of information that a customer master when collecting information from both online channel and offline channel is 1. The quantity of information refers to the percentage the product information a customer master occupies in all the information a customer can get about the product.

H4: Customers base their decisions whether to buy the product or not on the principle of utility maximization. If customers choose to buy a product from only one channel, they will not buy it if the utility is less than zero and buy it if the utility is equal or greater than zero.

H5: The added value of offline shopping is assumed to be zero. Shopping online can bring customers benefits of saving time, reducing transportation cost and etc. Meanwhile, customers may perceive risks that involve sellers, products, technology and themselves[13]. We assume the added value of shopping online follows even distribution $[-V_0,V_0]$. V_0 represents the maximum added value of shopping online.

According to the way that information is delivered to customers, product information can be categorized into two types: extrinsic quality information and intrinsic quality information[14]. The quantity of information delivered by online product reviews is a_1 and by expert comments, product introduction etc. is a_0. For intrinsic quality information can be delivered only when customers touch and try out the product, we can derive that $a_0+a_1<1$. Of all the customers who have scanned the website and are willing to buy the product, a_0+a_1 of them make consumption decisions on the basis of information provided by the website, while the others go to the offline retailer to search for more information.

As the information that a customer get about the product is incomplete and online product reviews are inconsistent (it is quite rare that all product reviews are positive or negative.), customer's perception of the product value is biased. We assume the perceived value is $(a_0+a_1)\theta V$. θ represents the positive rate. V represents the real value of the product. The proportion of purchase is

$$[(a_0+a_1)\theta V-P_1+V_0]/(2V_0) \tag{1}$$

The profit that the e-tailor makes from these customers is

$$(a_0+a_1)(P_1-C)[(a_0+a_1)\theta V-P_1+V_0]/(2V_0) \tag{2}$$

P_1 is the price fixed by the e-tailor. C represents the stock price and we assume that the stock prices of both channels are the same. In this paper other costs and income are not included.

$1-(a_0+a_1)$ of customers collect product information from both channels, and the quantity of information they master is 1.When customers collect information from both channels, benefits of shopping online do not exist and distribution of added value is $[-V_0,0]$ under such circumstances. After collecting all the information, customers make consumption decision based on the principle of utility maximization. When $P_0>P_1$, the proportion of customers who choose to buy the product from the e-tailor is $(P_0-P_1)/V_0$. When $P_0<P_1$, those customers choose to buy the product from the offline retailer.

2.1 E-tailor's pricing strategy when $P_0>P_1$

When $P_0>P_1$, part of customers go back to the e-tailor to buy the product, so the profit that the e-tailor make from the customers who collect information from both channels is

$$(1-a_0-a_1)(P_0-P_1)(P_1-C)/V_0 \tag{3}$$

Combining formulas (1), (2) and (3), we can get the total revenue of the e-tailor

$$\{(a_0+a_1)\,[(a_0+a_1)\theta V-P_1+V_0]+2(1-a_0-a_1)(P_0-P_1)\}(P_1-C)/(2V_0) \tag{4}$$

Customers give good reviews if the utility of buying the product is positive. For product reviews are made after getting the product, customers know all the information they need about the product. The utility of buying the product itself is $V-P_1$, and the positive rate of the product is

$$(V+V_0-P_1)/(2V_0) \tag{5}$$

We think the customers who collect product information from both channels know the product very well before purchasing it, so they are unlikely to make product reviews because the uncertainty about the product is eliminated.

Formula (5) is substituted into (4) to get the total profit of the e-tailor. Then the profit formula is derived to get the optimal pricing strategy of the e-tailor:

$$P_1=\frac{(a_0+a_1)^2V(V+V_0)+2(a_0+a_1)V_0^{\,2}+4V_0(1-a_0-a_1)P_0}{2[(a_0+a_1)^2V+4V_0-2V_0(a_0+a_1)]}+\frac{C}{2} \tag{6}$$

If the price of the offline retailer was more than V, no products would be sold by the offline retailer. So the customers who collect information from both channels do not quit buying the product. The proportion

of customers who decide to buy the product from the offline retailer after collecting information from both channels is $1-(P_0-P_1)/V_0$.The profit that the offline retailer makes from those customers is

$$(1- a_0-a_1)[1-(P_0-P_1)/V_0] (P_0-C) \quad (7)$$

We assume rules of profiting from the customers who collect information from both channels and those who only collect information from the offline channel are the same. So the offline retailer can maximize its total profit when the profit from the customers who collect information from both channels comes to its maximum. The formula (7) is derived to get the optimal pricing of the offline retailer

$$P_0=(V_0+P_1+C) / 2 \quad (8)$$

The e-tailor and the offline retailer adjust their prices according to each other's price quickly; the equilibrium of game is achieved at the end. Combining formulas (6) and (8), we can get the optimal pricing of the e-tailor

$$P_1 = \frac{(a_0 + a_1)^2 V (V + V_0 + C) - 4V_0 C (a_0 + a_1) + 2V_0 (V_0 + 3C)}{2V (a_0 + a_1)^2 - 2V_0 (a_0 + a_1) + 6V_0} \quad (9)$$

2.2 E-tailor's pricing strategy when $P_0<P_1$

When $P_1 \geq V_0+C$, customers who collect information from both channels buy the product from the offline retailer. In this case, the profit of the e-tailor is

$$\{-P_1[(a_0+a_1)V+2V_0]+(a_0+a_1)V(V+V_0)+2V_0^2\}(P_1-C)(a_0+a_1)/(4V_0^2) \quad (10)$$

The formula (10) is derived to get the optimal pricing of the e-tailor

$$[(a_0+a_1)(V+V_0)V+2V_0^2]/[2(a_0+a_1)V+4V_0]+0.5C \quad (11)$$

4 Analysis of model results

In the pricing models, all the parameters cannot be obtained directly except for C. V can be evaluated through C and product characteristics. V_0 changes with the development of electronic business and is also closely related with the product itself. To simplify our analysis, we take V_0=1and V=1.5C as an example. So $P_1=[(3.75C^2+1.5C)(a_0+a_1)^2-4C(a_0+a_1)+6C+2]/[3C(a_0+a_1)^2-2(a_0+a_1)+6]$

In Fig.1, there are three drawings above with the quantity as the abscissa and the optimal pricing of the e-tailor as the ordinate. They represent C=2, 5.18 and 8 respectively from left to right. C=5.18 is the critical value and all the optimal pricings just meet the condition $P_1<V_0+C$. When C=8, $0.58<a_0+a_1\leq 1$, and the optimal pricing P_1 is $[126(a_0+a_1)+9]/[12(a_0+a_1)+2]$ which is monotonically increasing. When C<5.18, the variation trend of the e-tailor's optimal pricing is the same as the first function. When C>5.18, the variation trend of the e-tailor's optimal pricing is the same as the third function.

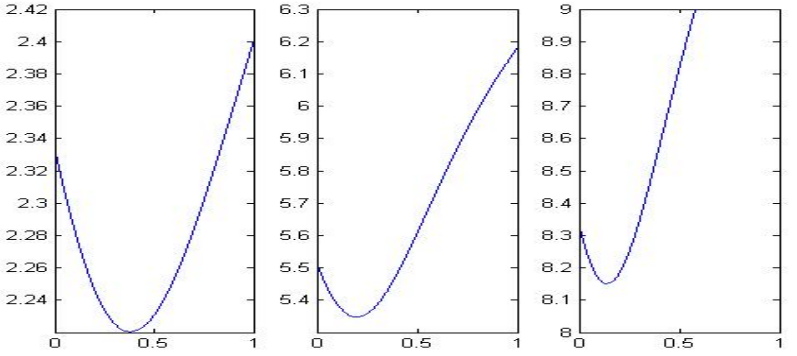

Fig. 1. The optimal pricings under different quantities of information

From the analysis results above, we can reach the conclusion that when C, V and V_0 remain the same, the e-tailor's optimal pricing decreases slightly at the early stage of the quantity of information's changing from 0 to 1. But afterward the e-tailor's optimal pricing increases with the increase of the quantity of information. In reality, the quantity of information provided by e-tailors exceed the quantity of information that minimize the pricing, so in general the optimal pricing of the e-tailor increase with the increase of the quantity of information. And the growth rate of the optimal pricing declines with the increase of the quantity of information. The changing rule of the optimal pricing of the offline retailer is the same as the e-tailor. But the growth rate of the offline retailer is smaller than the e-tailor. Particularly, when V_0/V is relatively small, there exists the critical value, which makes it possible for the e-tailor to fix a price that is higher than the offline retailer.

Of all the product information, the product description provides basic information like the brand and the size to meet the fundamental information needs of customers. E-tailors contain a wide variety of products which can reach more than million. All e-tailors try their best to provide detail information of the products and customers can return or change the product if their dissatisfaction is caused by the incompletion or inaccuracy of the product information. E-tailors make different policies to encourage customers to make product reviews. Some merchants of Taobao Mall provide points or other rewards to customers who actively make product reviews. Dangdang reward customers who comment on products with experience points which can be used to enter lucky drawings. Yihaodian give experience credits to customers who share their ideas on products. The incentive measures of e-tailors can effectively increase the quantity of product information and the sales price which result in higher gross profits.

5 Conclusions

The application of online product reviews in the pricing of electronic business is quite few. This paper combines the effect of online product reviews, product value, product cost and competition on the pricing of electronic business. The analysis results show that with the increase of product information, e-tailors are more motivated to fix a higher price.

This paper is of reference significance to the pricing of e-tailors, and it has several disadvantages. (1)The effects of stock and adverse logistics on pricing of e-tailors are not included in our model. (2) The added value of shopping online and product value cannot be measured accurately. (3) The effect of customers who don't surf the internet on pricing is not analyzed and needs to be improved.

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